

METHOD FOR CONTROLLING THE SPEED OF A VEHICLE

## Related Art

The present invention is based on a method for controlling the speed of a motor-vehicle according to the species defined in the main claim.

- 5 From DE 195 37 273 A1 it is known to trigger wear-free, additional deceleration devices such as retarders with the aid of a speed control. Retarders, and engine brakes as well, may be used to maintain a constant vehicle speed on a downhill grade in those instances where an intervention in the engine control alone may be insufficient to maintain a slow speed. The additional deceleration devices must be
- 10 differentiated from the service brakes of a vehicle.

## Summary of the Invention

- In contrast, the method according to the present invention for controlling the speed of a motor vehicle having the features of the main claim has the advantage that a
- 15 service brake of the vehicle is activated when an actual speed of the vehicle exceeds a predefined setpoint speed by more than a first predefined speed difference. In this way the functionality of the driving speed control may be expanded in such a way that the speed is able to be maintained on downhill road sections, for instance, even in those cases where the drag torque of the vehicle's drive train fails to generate
- 20 sufficient braking action. The driving speed control may thus be utilized to a greater extent, which increases the driving comfort.

- Advantageous further developments and improvements of the method indicated in the main claim are rendered possible by the measures specified in the dependent
- 25 claims.

- It is particularly advantageous if the service brake is activated only when other measures, such as reducing the torque demand of the driving speed control, an idle speed control, a deceleration fuel cutoff and/or an additional activation of one or a
- 30 plurality of ancillary components do not lead to sufficient braking action to adequately adjust the actual speed of the vehicle to the predefined setpoint speed. In this way the driving speed control, and thus the service brake, may be realized in a gentle

manner prior to activation of the service brake, by utilizing the engine braking action. If the service brake is activated in addition when the engine braking action is active, stronger braking action may be achieved and the driving speed control maintained even in a pronounced downhill gradient, i.e., the actual speed of the vehicle may be sufficiently adjusted to or brought within the range of the predefined setpoint speed in the case of a steep downhill gradient as well.

Another advantage is that the service brake will be deactivated when the actual speed drops below the setpoint speed again. With appropriate selection of the first predefined speed difference, a continual deactivation and activation of the service brake is avoided, which increases the driving comfort.

It is particularly advantageous if the idle speed control is deactivated for as long as the service brake is activated. This saves fuel when the service brake is activated.

Support of the service brake by the engine brake may be obtained by activating the deceleration-fuel cutoff for as long as the service brake remains activate.

Another advantage results if the fuel cutoff on deceleration is activated when the actual speed exceeds the setpoint speed by a fourth predefined speed difference, which is greater than a second predefined speed difference at which the idle-speed control is activated. This activates the fuel cutoff on deceleration only if the braking action achieved by the idle speed control has been insufficient during adjustment of the actual speed of the vehicle to the predefined setpoint speed. This increases the driving comfort, since it avoids an excessive lowering of the torque as it happens in a direct fuel cutoff on deceleration without prior idle speed control.

#### Brief Description of the Drawing

An exemplary embodiment of the present invention is represented in the drawing and explained in greater detail in the following description.

The figures show:

Fig. 1      A block diagram with components for realizing the method according to the present invention;

Fig. 2 a flow chart for an exemplary sequence of the method according to the present invention;

5 Fig. 3 a) The profile of the actual speed of the vehicle over time;

Fig. 3 b) The profile of the torque request of the driving speed control over time;

10 Fig. 3 c) The profile of the idle speed control over time;

Fig. 3 d) The profile of the fuel cutoff on deceleration over time; and

Fig. 3 e) The profile of a request to the service brake of the vehicle over time.

## 15 Detailed Description

Reference numeral 10 in Figure 1 denotes a control unit of a motor vehicle, which is connected to a service brake 1 of the motor vehicle – generally a friction brake that is subject to wear -, an idle speed control 5, one or more ancillary components 15, and a driving speed control 20. In addition, a speedometer 25 is provided, which  
20 measures the actual speed of the vehicle and is connected to vehicle control 10 and driving speed control 20. Speedometer 25 transmits the actual instantaneous speed of the vehicle to vehicle control 10 and driving speed control 20.

In this exemplary embodiment vehicle control 10 constitutes an expanded engine control, which not only controls the engine of the vehicle but service brake 1 of the  
25 vehicle as well.

In the activated state, driving speed control 20 transmits a torque request to vehicle control 10, which vehicle control 10 implements in a manner not shown, by  
30 appropriate adjustment of the ignition firing point, the injection duration or the air supply into the combustion chamber of the motor vehicle, for instance.

Figure 2 describes the method according to the present invention on the basis of a flow chart by way of example. The program is started upon activation of driving

speed control 20, for instance by the driver of the vehicle using a cruise control lever. In a program point 100 driving speed control 20 checks whether the actual speed of the vehicle is greater than the predefined setpoint speed. If this is the case, the program branches to program point 105, otherwise the program branches to a  
 5 program point 155.

In program point 155 the current torque request of driving speed control 20 will be maintained if the actual speed corresponds to the predefined setpoint speed, or it will be raised if the instantaneous speed is lower than the predefined setpoint speed.

10 The method subsequently branches back to program point 100.

In program point 105 driving speed control 20 reduces the torque request to vehicle control 10. The torque request may be reduced by a suitably selected predefined decremental value, for instance, and the increase in the torque request, described in  
 15 connection with program point 155, may be realized by a likewise suitably selected, predefined incremental value. After program point 105 the program branches to a program point 110.

In program point 110 driving speed control 20 ascertains whether the actual speed  
 20 exceeds the predefined setpoint speed by more than a second predefined speed difference. If this is the case, the program branches to a program point 115, otherwise the program branches back to program point 100.

In program point 115 an activation signal is set in driving speed control 20 and  
 25 transmitted to vehicle control 10. Upon receipt of the set activation signal, vehicle control 10 initiates an activation of idle speed control 5 in program point 115, thereby reducing the torque request of the activated ancillary components of the vehicle, such as the air condition system or the generator. The program then branches to a  
 program point 120.

30 In program point 120 vehicle control 10 checks whether the actual speed exceeds the predefined setpoint speed by less than a third predefined speed difference, which is smaller than the second predefined speed difference. If this is the case, the

program branches to a program point 150, otherwise the program branches to a program point 125.

In program point 150 vehicle control 10 initiates a deactivation of idle speed control

- 5 5. As soon as driving speed control 20 determines that the actual speed once again exceeds the predefined setpoint speed by less than the third predefined speed difference, it initiates the resetting of the activation signal. After program point 150, the program branches back to program point 100.

In program point 125 vehicle control 10 ascertains whether the actual speed exceeds  
10 the predefined setpoint speed by more than a fourth predefined speed difference, which is greater than the second predefined speed difference. If this is the case, the program branches back to a program point 130, otherwise the program branches to program point 120.

- 15 In program point 130 vehicle control 10 initiates the activation of a fuel cutoff on deceleration of the vehicle by interrupting the injection of fuel, for instance, and it deactivates idle speed control 5. The program then branches to a program point 140.

- 20 In program point 140 vehicle control 10 ascertains whether the actual speed exceeds the predefined setpoint speed by less than a fifth predefined speed difference, which is greater than the second predefined speed difference and smaller than the fourth predefined speed difference. If this is the case, the program branches to a program point 145, otherwise the program branches to a program point 165.

- 25 In program point 145 vehicle control 10 initiates a deactivation of the deceleration fuel-cutoff, i.e., in this example, it restores the fuel supply. Vehicle control 10, using an additional suitable activation signal, for instance, subsequently causes driving speed control 20 to resume the program in program point 110.

- 30 In program point 165 vehicle control 10 ascertains whether the actual speed exceeds the predefined setpoint speed by more than a sixth predefined speed difference, which is greater than the fourth predefined speed difference. If this is the case, the program branches to a program point 170, otherwise the program branches back to program point 140.

In program point 170 vehicle control 10 initiates the activation of one or more previously non-activated ancillary components, which require additional drag torque in an the activated deceleration fuel-cutoff and thereby generate additional braking  
5 action. If no further activatable ancillary components are present in the vehicle and provided the actual speed exceeds the predefined setpoint speed by more than the sixth predefined speed difference, it is branched from program point 165 directly to a program point 185. However, if program point 170 is executed, branching to a program point 175 will take place subsequently.

10 In program point 175 vehicle control 10 ascertains whether the actual speed exceeds the predefined setpoint speed by less than a seventh predefined speed difference, which is smaller than the sixth predefined speed difference and greater than the fourth predefined speed difference. If this is the case, the program branches to a  
15 program point 180, otherwise the program branches to program point 185.

In program point 180 vehicle control 10 initiates a deactivation and thus deenergization of the ancillary component(s) which had additionally been activated or energized in program point 170. The method then branches back to program point  
20 125.

In program point 185 vehicle control 10 ascertains whether the actual speed exceeds the predefined setpoint speed by more than a first predefined speed difference, which is greater than the sixth predefined speed difference. If this is the case,  
25 branching to a program point 190 will take place; otherwise, in the event that one or more additional ancillary components had been switched on or activated in program point 170, it is branched back to program point 175. However, if the actual speed does not exceed the predefined setpoint speed by more than the first predefined speed difference, it is branched from program point 185 back to program point 140.

30 In program point 190, vehicle control 10 initiates an activation of service brake 1 of the vehicle, whereupon the program branches to a program point 195.

In program point 195 vehicle control 10 checks whether the actual speed is lower than the predefined setpoint speed. If this is the case, the program is exited, otherwise the program branches back to program point 195. If the actual speed is less than the predefined setpoint speed, this is also detected by vehicle control 20, which then resets the activation signal it had set.

If driving speed control 20 is still active the described program will be run through again.

10 In Figure 3a the method according to the present invention is illustrated with the aid of an exemplary profile of the difference between the actual speed of the vehicle and the predefined setpoint speed over time  $t$ . The actual speed is denoted by  $v_{act}$ , and the predefined setpoint speed is denoted by  $v_{setpoint}$ , so that the difference plotted over the ordinate is  $v_{act} - v_{setpoint}$ . For the difference  $v_{act} - v_{setpoint}$ , the first predefined speed difference is denoted on the ordinate, by KLDVBROB, and amounts to 4 km/h, for example.

The second predefined speed difference is denoted by DVLLVO in Figure 3a) and amounts to 2 km/h by way of example. The third predefined speed difference is denoted by DVLLVU in Figure 3a) and amounts to 1.5 km/h, for instance. The fourth predefined speed difference is denoted by DVSAVO in Figure 3a) and amounts to 3 km/h by way of example. The fifth predefined speed difference is denoted by DVSAVU in Figure 3a) and amounts to 2.5 km/h, for instance. The sixth and seventh predefined speed differences are not shown in Figure 3a) since it is assumed in this example that no additional ancillary components will be activated.

Second predefined speed difference DVLLVO and third predefined speed difference DVLLVU bring about a hysteresis and prevent a continual activation and deactivation of idle speed control 5 when difference  $v_{act} - v_{setpoint}$  fluctuates by the second predefined speed difference DVLLVO. Correspondingly, fourth predefined speed difference DVSAVO and fifth predefined speed difference DVSAVU cause a hysteresis and prevent a continual switch between deceleration fuel-cutoff and idle speed control when difference  $v_{act} - v_{setpoint}$  fluctuates by the fourth predefined speed difference DVSAVO.

In addition, the present invention may provide that service brake 1, activated for controlling the driving speed, is deactivated again only when predefined setpoint speed  $v_{\text{setpoint}}$  exceeds actual speed  $v_{\text{act}}$  by more than a predefined termination value, which is denoted by DVLLVUBR in Figure 3a). For the flow chart shown in Figure 2 this means that vehicle control 10 checks at program point 195 whether the predefined setpoint speed exceeds the actual speed by more than the predefined termination value DVLLVUBR. If this is the case, the program is exited, otherwise the program branches back to program point 195. In this manner a hysteresis is also realized for the activation of the service brake to control the driving speed, such hysteresis preventing an excessive switching between the engine brake and the service brake of the vehicle.

In Figure 3a), difference  $v_{\text{act}} - v_{\text{setpoint}}$  increases from instant  $t=0$  up to a first instant  $t_1$  and reaches second predefined speed difference DVLLVO at first instant  $t_1$ . Figure 3b) shows the torque request of the driving speed control over time  $t$ , the torque request being denoted by  $\text{mrfr}_w$ . The increase in difference  $v_{\text{act}} - v_{\text{setpoint}}$  up to first instant  $t_1$  results in a reduction of torque request  $\text{mrfr}_w$  down to zero even before first instant  $t_1$  is reached. Figure 3c), by means of a logical value, illustrates over time  $t$  whether or not idle speed control 5 is activated. In Figure 3d) it is shown over time  $t$  with the aid of a logical value whether or not the deceleration fuel-cutoff is activated. Figure 3e) illustrates over time  $t$  by means of a logical value whether a brake request for the activation of service brake 1 is present for driving speed control 20.

From instant  $t=0$  to first instant  $t_1$  the logical values for the idle speed control, deceleration fuel-cutoff and the brake request are equal to zero, i.e., the idle speed control, the deceleration fuel-cutoff and the service brake are not activated. At instant  $t_1$ , difference  $v_{\text{act}} - v_{\text{setpoint}}$  exceeds the second predefined speed difference DVLLVO. This leads to the activation of the idle speed control whose logical value is set at instant  $t_1$ . The logical values for the deceleration fuel-cutoff and the brake request remain equal to zero, so that the deceleration fuel-cutoff and the service brake continue to be deactivated. Since torque request  $\text{mrfr}_w$  has gone back to zero even before first instant  $t_1$  was reached, the torque request of the activated



ancillary components is able to be reduced as well by activation of the idle speed control, so that an additional braking action is achieved by the drag torque of the drive unit of the vehicle. Difference  $v_{act} - v_{setpoint}$  continues to increase from first instant  $t_1$  up to a second instant  $t_2$ , and at second instant  $t_2$  exceeds fourth

5 predefined speed difference DVSAVO. At second instant  $t_2$  the logical value for the deceleration fuel-cutoff is therefore set and the deceleration fuel-cutoff activated, whereas the idle speed control is deactivated at second instant  $t_2$  and the logical value for the idle speed control is reset. The logical value for the brake request continues to remain equal to zero, so that service brake 1 stays deactivated. Due to

10 the deceleration fuel-cutoff, the engine braking initiated by idle speed control 5 is amplified in its effect as a result of the fuel supply being switched off. Any torque requests of the activated ancillary components are reduced to zero in the process. Since idle speed control 5 is activated between first instant  $t_1$  and second instant  $t_2$ , the transition to the point where the torque requests of the activated ancillary

15 components are reduced to zero will not occur abruptly, so that the driving comfort is not overly affected.

First instant  $t_1$  follows instant  $t = 0$ . Second instant  $t_2$  follows first instant  $t_1$ .

20 Between second instant  $t_2$  and a subsequent third instant  $t_3$ , difference  $v_{act} - v_{setpoint}$  reaches a maximum value, which is smaller than first predefined speed difference KLDVBROB, however, so that service brake 1 will not be activated. Due to the braking action achieved by the activated deceleration fuel-cutoff, difference  $v_{act} - v_{setpoint}$  then drops again, and at third instant  $t_3$  falls below fifth predefined

25 speed difference DVSAVU. At third instant  $t_3$ , the deceleration fuel-cutoff is therefore deactivated again and the logical value for the deceleration fuel-cutoff set back, whereas the idle speed control is reactivated again at third instant  $t_3$  and its logical value is set.

30 It is also possible, of course, that a lower gradient of the road stretch was a contributing factor in the reduction of difference  $v_{act} - v_{setpoint}$  as well. At fourth instant  $t_4$  following third instant  $t_3$ , difference  $v_{act} - v_{setpoint}$  then drops below third predefined speed difference DVLLVU, so that the idle speed control will be deactivated again at fourth instant  $t_4$  as well and its logical value set back to zero.

Between fourth instant  $t_4$  and a subsequent fifth instant  $t_5$ , difference  $v_{act} - v_{setpoint}$  reaches a minimum that is greater than zero and smaller than third predefined speed difference DVLLVU. Between fourth instant  $t_4$  and fifth instant  $t_5$ , driving speed control 20 is therefore able again to be realized by a torque request  $mrfr\_w \geq 0$ . Between fourth instant  $t_4$  and fifth instant  $t_5$ , idle speed control, deceleration fuel-cutoff and service brake 1 are deactivated. Difference  $v_{act} - v_{setpoint}$  increases again up to fifth instant  $t_5$ , so that torque request  $mrfr\_w$  of driving speed control 20 is reduced once more. At fifth instant  $t_5$ , difference  $v_{act} - v_{setpoint}$  exceeds second predefined speed difference DVLLVO, so that torque request  $mrfr\_w$  has returned to zero at fifth instant  $t_5$ , and idle speed control 5 is reactivated by setting the logical value.

Starting with fifth instant  $t_5$ , difference  $v_{act} - v_{setpoint}$  rises once more and at a sixth instant  $t_6$ , which follows fifth instant  $t_5$ , exceeds fourth predefined speed difference DVSAVO again. As a result, idle speed control 5 is reactivated at sixth instant  $t_6$  by having its logical value reset to zero, and the deceleration fuel-cutoff is reactivated by setting of its logical value. Service brake 1 remains deactivated. Starting with sixth instant  $t_6$ , difference  $v_{act} - v_{setpoint}$  continues to increase and exceeds first predefined speed difference KLDVBROB at seventh instant  $t_7$ , which follows sixth instant  $t_6$ . At seventh instant  $t_7$ , service brake 1 will therefore be activated, the logical value of the brake request being set at seventh instant  $t_7$ . The deceleration fuel-cutoff remains activated as before, so that service brake 1 is aided by the engine brake realized by the deceleration fuel-cutoff. Shortly after seventh instant  $t_7$ , difference  $v_{act} - v_{setpoint}$  reaches a maximum above first predefined speed difference KLDVBROB and then drops in a relatively steep manner due to the braking action and possibly as a result of a downhill slope whose gradient is decreasing again. At an eighth instant  $t_8$  which follows seventh instant  $t_7$ , difference  $v_{act} - v_{setpoint}$  then drops below the predefined switch-off instant DVLLVUBR, so that service brake 1 is deactivated at eighth instant  $t_8$ , the logical value of the brake request is set back to zero, the deceleration fuel-cutoff is deactivated as well and the logical value reset to zero, the idle speed control deactivated, the logical value remaining set back. Starting with eighth instant  $t_8$ , driving speed control 20 may then be implemented again with the aid of torque request  $mrfr\_w$ , which begins to rise again beginning with eighth instant  $t_8$ .

The profile of difference  $v_{\text{act}} - v_{\text{setpoint}}$  in Figure 3a) has been selected as an example and may result from a road section that has downhill gradients of different magnitudes; between instant  $t = 0$  and fourth instant  $t_4$ , a low gradient is present, and  
 5 between fifth instant  $t_5$  and eighth instant  $t_8$  a more pronounced gradient occurs, which also results in a greater difference  $v_{\text{act}} - v_{\text{setpoint}}$ .

Furthermore, in the example in Figure 3 it can be seen that the deceleration fuel-cutoff is activated as well when service brake 1 is activated, but not idle speed  
 10 control 5.

According to the described exemplary embodiment, the driving speed control has a stepped profile. As difference  $v_{\text{act}} - v_{\text{setpoint}}$  of the driving speed increases, the initial response is a reduction of the torque request of driving speed control 20,  
 15 followed in a second step by activation of idle speed control 5, and thus a reduction of the torque request of activated ancillary components, followed in a third step by deceleration fuel-cutoff and thus an interruption of the fuel injection in this example and, finally, in a fourth step, an activation of the service brake. It need not necessarily be the case that all mentioned steps are initiated as a function of the  
 20 maximally achieved difference  $v_{\text{act}} - v_{\text{setpoint}}$ ; this will depend on the predefined speed differences that are exceeded by the difference  $v_{\text{act}} - v_{\text{setpoint}}$ .

The exemplary embodiment shown in Figure 3 does not include the step according to Figure 2 in which additional ancillary components are switched in when the sixth predefined speed difference is exceeded. Essential for the present invention is the  
 25 activation of the service brake when difference  $v_{\text{act}} - v_{\text{setpoint}}$  of the driving speed exceeds the first predefined speed difference. The additional steps of activation of the deceleration fuel-cutoff, activation of the idle speed control and/or activation of one or a plurality of further ancillary components may be provided optionally and in addition, in any desired combination. If the steps of deceleration  
 30 fuel-cutoff and idle speed control are both provided, it is possible – as described in Figure 3 – to deactivate the idle speed control when deceleration fuel-cutoff is activated.

The step according to Figure 3b) in which the torque request is modified constitutes the usual driving speed control, which according to the present invention is aided by the service brake and possibly the engine brake in those instances only where the difference  $v_{\text{act}} - v_{\text{setpoint}}$  of the driving speed exceeds the corresponding predefined speed differences and a pure adaptation of the torque request is no longer sufficient to control the driving speed.

If service brake 1 is activated, difference  $v_{\text{act}} - v_{\text{setpoint}}$  in the specific embodiment according to Figure 3 is reduced in that the normal closed-loop control of vehicle control 20 is resumed by varying the torque request according to Figure 3b) only when the service brake has been deactivated again at eighth instant  $t_8$  on account of difference  $v_{\text{act}} - v_{\text{setpoint}}$  dropping below predefined switch-off point DVLLVUBR. Only following eighth instant  $t_8$  will an engine torque then be requested again by vehicle control 20. Due to the fact that according to Figure 3e) and Figure 3d) deceleration fuel-cutoff is activated as well between seventh instant  $t_7$  and eighth instant  $t_8$  when service brake 1 is activated, and, according to Figure 3c, idle speed control 5 is deactivated when deceleration fuel-cutoff is activated, both the hysteresis of the idle speed control and the hysteresis of deceleration fuel-cutoff are deactivated in the exemplary embodiment of Figure 3 given an activated service brake 1. The exemplary embodiment of Figure 3 implements the flow chart according to Figure 2, with the sole exception that – as described – in the exemplary embodiment according to Figure 3 the step of switching in one or a plurality of additional ancillary components when difference  $v_{\text{act}} - v_{\text{setpoint}}$  of the vehicle speed exceeds the sixth predefined speed difference is not realized.

The predefined speed differences may be suitably selected or applied in such a way, for instance, that the idle speed control sets in only when the torque request of driving speed control 20 has already been reduced down to zero, and the deceleration fuel-cutoff only sets in when all torque requests of activated ancillary components have already been reduced to zero with the aid of idle speed control 5. The first predefined speed difference may be specified such, for instance, that the activation of service brake 1 occurs only when the engine braking action realized by the deceleration fuel-cutoff and possibly further activation of one or a plurality of ancillary components has already reached a maximum value.